NASA TT F-11,136

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Translation of "Ekstremal'nyye faktory dlitel'nogo kosmicheskogo poleta i trebovaniya k sostoyaniyu zdorov'ya chlenov ekipazhey kosmicheskikh korabley". Kosmicheskaya Biologiya i Meditsina, Vol.I, No.2, pp.52-54, 1967.

N67-36480
(ACCESSION NUMBER)
4
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
FACILITY FORM 602
(THRU)
1
(CODE)
04
(CATEGORY)

GPO PRICE $ _____

CFSTI PRICE(S) $ _____

Hard copy (HC) 3.00

Microfiche (MF) .65

ff 653 July 65

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 AUGUST 1967

EXTREMAL FACTORS OF LONG-TERM SPACE FLIGHT AND HEALTH REQUIREMENTS FOR SPACECRAFT CREWS

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P.V.Buyanov and V.G.Terent'yev

ABSTRACT. Medical selection of spacecraft crews for long-duration space missions is discussed. In view of individual differences in functional limits and tolerance to flight factors, it is suggested to base physical aptitude requirements for candidates on the effect of environmental space flight factors upon the human organism and its tolerance limits. Positive selection is predicated on satisfactory resistance to space-simulation tests (acceleration, physical stress, oxygen starvation, orthostatic tests).

Research in recent years as to the effect of space flight on the crew of a spacecraft, together with the experimental study of individual factors of flight, have disclosed a number of regular changes in various organs and systems of the human body.

Certain flight factors, for example liftoff and reentry accelerations, are close to the boundary of tolerance even for a healthy, well-trained body. As yet, we know practically nothing on the extent of the adverse effect of prolonged weightlessness on the human organism. However, simulation of certain elements of weightlessness and hypokinesis under laboratory conditions does permit postulating, with a certain degree of probability, that the factors of long-duration flights may be extremal for the organism of astronauts. A flight complicated by emergency situations is poorly tolerated by the crew.

At present, active search is going on to develop methods for overcoming the adverse effects of the factors and conditions of future space flights on the human organism. One such method is the standardization of medical health requirements for astronauts, with respect to selection and training for flight.

Many authors hold that a perfect state of health is a prerequisite for work under the protracted action of space flight factors. In their opinion, candidates with even the slightest deviation from norm in the functional condition of the body are absolutely unfit for long-duration space flights.

This approach to the medical examination of astronauts is unjustified, since most healthy individuals have various organic peculiarities, some of which might restrict the occupational activity of the astronaut while others might have no appreciable influence in this respect. Since there are no empirical data as to direct observation of astronauts who have undertaken long-duration flights, one must be satisfied with competent evaluation of their functional

* Numbers in the margin indicate pagination in the foreign text.

state to determine the manner in which the various characteristics of the organism will affect tolerance for the flight factors simulated under laboratory conditions.

Our data, like those of other authors (Dietlein, Colcome, and others) permit the postulating that the state of weightlessness and limited mobility characteristic of long-duration space flight will lead to disorders of the water-salt metabolism, to disturbance in the polyhormonal function and in the reflex regulation of cardiovascular activity, to a change in vasotonia, and to a decline in tolerance for physical exercise (P.V.Buyanov; L.I.Kakurin et al.) and for radial accelerations (A.R.Kotovskaya and Ye.M.Yuganov).

The adaptivity of the organism under conditions of weightlessness, in the opinion of many authors, is limited by the reduction in orthostatic stability which is connected with the modified afferentation, primarily as a result of /53 the considerable decrease in hydrostatic pressure of the blood, its redistribution over the vascular regions, and the decreased volume of the systemic circulation. In addition, emotional stress during a space flight may promote premature development of atherosclerotic changes (Vorel; D.S.Kuleshov and L.S.Isaakyan; F.P.Kosmolinskiy; and others).

Prolonged limitation of mobility leads to osseous decalcification (David) and predisposes to the calculi formation in the urinary tract (Cocett et al.). The formation of concrements is connected mainly with disturbance of the water balance and reduction in muscular activity (Lawton).

We consider that the changes in the atmosphere of the spacecraft may cause disorders of respiratory function, produce inflammation of the mucosae of the respiratory tract, and aggravate latent processes in the lungs. The radical qualitative and quantitative changes in diet, in combination with other flight factors, may cause functional disorders in the gastrointestinal tract, and induce dysbacteriosis, auto-intoxication, disturbance in metabolism, etc.

Isolation, changed afferentation, and emotional stress, all contribute to impairment of neuropsychic activity. Functional disturbances of the nervous system under these conditions may be superseded by a more serious symptomatology (Bom; Russ). People with nervous and emotional disorders often show impaired resistance to radial acceleration (P.M.Suvorov and M.G.Papkov) and to vestibular irritation (I.P.Tatarinov). Prolonged stay in a closed space under the conditions of isolated life promotes disturbance of the immunobiological properties of the body.

Thus the medical health requirements for crew members of spacecraft intended for long-duration missions must primarily allow for the influence exerted by the flight factors on human organisms with certain specific functional peculiarities, and also for the limits within which the functional characteristics play no substantial role for tolerance of long-duration space flights.

Experimental studies and medical examination of astronauts following orbital flight have permitted the development of basic health requirements for crews on prolonged flights.

Studies have shown that clinically healthy persons have individually different limits of functional capabilities, by which the tolerance for flight factors is determined. A prerequisite for medical acceptance, taking account of these functional capabilities, is satisfactory tolerance to standardized dynamic tests. The most informative of these tests comprise the action of accelerations, as well as physical exercise, passive change of body position (orthostatic test), oxygen want, and high temperature. No unified methodical procedures for evaluating the functional tests are as yet in existence. In view of the significance of the functional examination methods, medical examination of astronauts must, in the near future, provide for standardization of stress tests with reference to the features of space flight.

An analysis of the data showed that certain peculiarities in the state of health do not contraindicate prolonged space flights if, on application of functional tests and under simulation of certain flight factors, the adaptive faculties of the body are not impaired. A number of functional characteristics of reaction to extremal conditions, however, constitute direct contraindications to long-duration space flight. /54

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Translated for the National Aeronautics and Space Administration by the O.W.Leibiger Research Laboratories, Inc.